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THE CONVOLUTION OF THE TRACHEA IN THE SANDHILL AND WHOOPING CRANES.

BY THOMAS S. ROBERTS.

IT is well known to ornithologists, that in many birds there are various peculiar modifications of the trachea, or windpipe, which, it is supposed, serve the purpose of adding some particular quality to the voice. Passing by the numerous minor instances of this structure as seen frequently in ducks, in some geese and a few other birds, we find it most strikingly exhibited among the cranes and swans. In certain species of these two groups the trachea enters the enlarged and excavated keel of the sternum, and after a number of convolutions, varying in position and extent with the species, passes out at the place of entrance and thence into the lungs. In such cases, at least, it is plainly great strength and volume of tone which are imparted, as is clearly evidenced by the powerful utterances for which these birds are noted.

It is the present purpose to speak of this point of structure only as it exists in the two American species of cranes, *Grus americana* and *Grus canadensis*, with special attention called to its presence in the latter.

That the trachea is remarkably convoluted within the sternum in the whooping crane (*G. americana*) has been pointed out and fully described by Dr. Elliott Coues, in his "Birds of the Northwest." But the mistake is there made of stating (on the evidence of others, I believe) that in the sandhill crane (*G. canadensis*) the trachea is simple; and this supposed entire difference between the two species is presented as strong anatomical evidence of their distinctness.

The fact is, however, that the trachea *is* convoluted within the keel in the sternum in *G. canadensis* as well as in *G. americana*. This I have determined by the examination of four sterna of *canadensis*, three of which were prepared by myself from birds positively identified as *canadensis* by the generally recognized external characters. Two sterna of *americana* have been examined: one the same that was described by Dr. Coues, and with which I have had the opportunity of comparing specimens through the courtesy of Dr. R. O. Sweeny, president of the St. Paul Academy of Natural Sciences; the other a specimen recently prepared by Mr. Wm. Howling, taxidermist, of Minneapolis, Minn., and in whose collection I saw the adult bird from which it was taken. One side of the keel was neatly cut away by Mr. Howling, at my suggestion, and the specimen freely offered for use in the present connection. It is identical in structure with the St. Paul specimen, and is the one from which the drawing has been made.

Although there is not such a radical difference as supposed by Dr. Coues, yet the two species are distinct in respect to their tracheal and sternal development. A glance at the drawings will show this at once. They are alike in so far as the trachea enters the sternal keel in each. But in *canadensis* the whole sternum is smaller and less stoutly developed; the coils of the windpipe are confined to the anterior half of the keel, and it is this portion alone that is enlarged; there are only about eight inches (average of four specimens) of windpipe in the keel, to twenty-seven inches (average of two specimens) in *americana;* the walls of the sternal cavity are much more imperfectly ossified than in *americana*, where they are everywhere on the outside dense, hard bone. On

the whole the entire conformation of the trachea and sternum in *canadensis* is much simpler than in *americana*.

Although only the anterior portion of the keel is enlarged for the reception of the trachea in *canadensis*, yet the remainder of

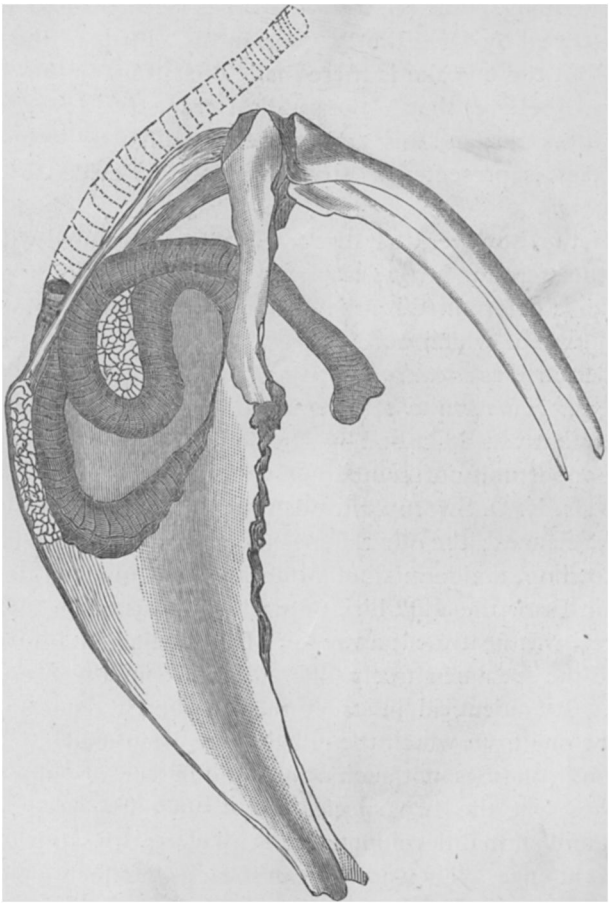

FIG. I—*GRUS CANADENSIS.*

the keel is not solid bone; but, instead, is composed of two frail plates separated by a thin layer of bony meshwork. This light structure of the posterior part of the keel is more pronounced in some specimens than in others, reaching the greatest development yet seen, in a sternum which shows also the greatest convolution of the trachea.

The following short description of the course of the trachea within the keel in *canadensis* will be sufficient in connection with the drawing presented: Entering the keel at its lower anterior angle, the trachea follows the lower edge of the keel for about an

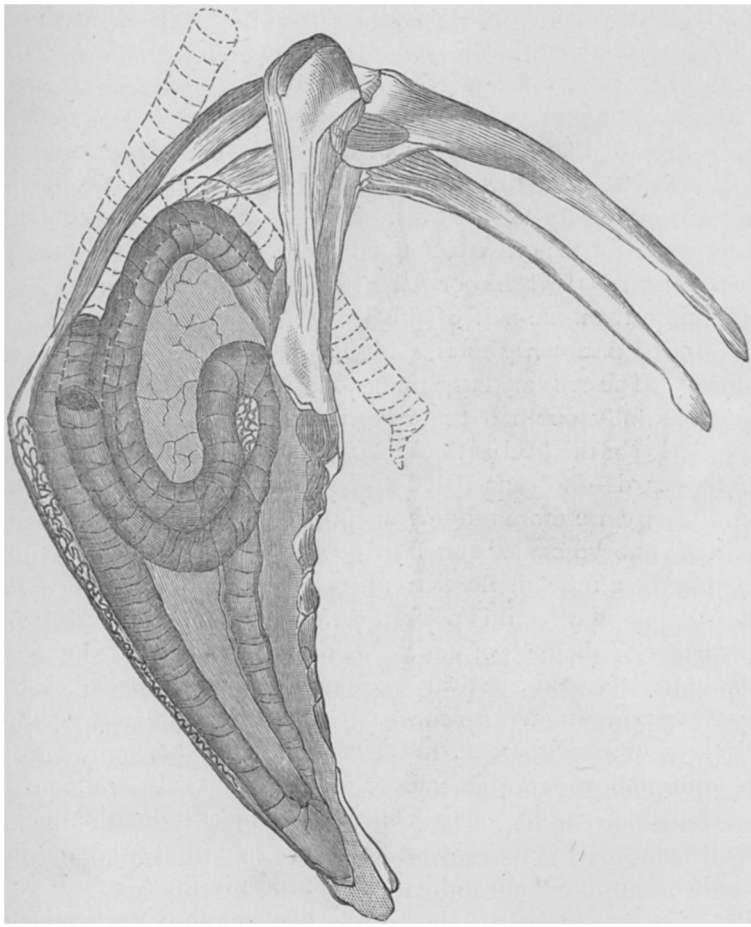

FIG. II—*GRUS AMERICANA.*

inch and then curves strongly upward and forward, until it has turned nearly one-half of a circle, when it passes by a scarcely perceptible curve to the upper anterior point of the sternum; lying for a part of the distance in a groove formed for its reception in the body of the bone and which is visible as a semi-cylindrical projection on the inner surface of the sternum in front.

From here the trachea reaches the point of entrance by a strong double curve, forming a figure which is a perfect letter S, the lower turn being within the first large coil, and the upper following the anterior outline of the keel. The cavity is three and one-quarter inches long, just one-half of the entire length of the keel. There are two unoccupied spaces between the coils—a small one filled with bony meshwork and a larger one entirely hollow. This description is from the specimen figured, which has been selected as representing very nearly the average of four. Two others show some variations worthy of mention. In a large sternum from a female bird, there is less convolution and fully two inches less of windpipe inside the keel. The upper loop does not fill the anterior part of the cavity, and on entering the keel the trachea does not go as far back or form the same kind of curve. But little more than one-half of the length of the keel is excavated. The third specimen shows a higher development than the one figured. The coils are large and occupy nearly the entire hollow, which is fully one-half the length of the keel. The posterior lower edge of the keel is thickened—much like the same part further forward—and cancellated inside; while the walls of the anterior cavity are more fully ossified than in either of the others.

In an embryo crane,[1] stated to be the sandhill, which was just about to break the shell when collected, the trachea does not enter the sternum at all and is perfectly simple. But the anterior part of the keel, which is, of course, entirely cartilaginous and very diminutive, is, comparatively speaking, much thickened, and a cross section shows it to consist of two thin walls separated by a marrow-like substance. In this feature of the sternum, we see the only indication in the embryo of the singular structure to be developed later in life. The degree of complexity of the trachea is thus shown to be dependent upon age, and the variations just alluded to are no doubt fully accounted for by this fact.

It is unnecessary to frame a new description of the convolutions of the trachea in *americana*, as that furnished by Dr. Coues is excellent. The following extracts from it are given for the convenience of the reader. "The sternal keel is broad and tumid, and is entirely excavated. The greater part of the excavation is occupied by the singular duplications of the trachea; * * but

[1] This specimen was obtained in the northwestern part of Minnesota, by Mr. Nathan Butler, and is now in the collection of the Minn. Acad. of Nat. Sci., Minneapolis, Minn.

there are two—an anterior and a posterior—large empty air cells in the bone, with smooth walls, and two other air cells—one superior and one along the edge of the keel—filled with light bony meshwork. * * * The trachea, entering the apex of the keel, traverses the whole contour of the keel in a long vertical coil, emerges at the front upper corner of the keel, enters again at the lower corner of the keel, and makes a smaller vertical coil in the center, emerging again where it went in. On looking at the object from the front, we see three parallel vertical coils side by side; the middle one is the trachea coming down from the neck above; on the left hand is the bulge of the first great coil; on the right is the windpipe passing to the lungs after it has made its second coil inside."[1] Following this is a statement to the effect that "there are about twenty-eight inches of windpipe coiled away in the breast-bone," and that altogether, from the upper larynx to the bronchi, the trachea is fifty-eight inches in length, and this in a bird that is little over four feet long from the tip of the bill to the end of the tail.

The average of three specimens shows the entire length of the trachea in *canadensis* to be about twenty-seven inches.

Audubon, who regarded *G. canadensis* as the young of *G. americana*, has, curiously enough, left us a description of the tracheal apparatus of the former but not of the latter. His description is taken from the sternum of a crane which he kept for a season in confinement, and which the reader would be led to infer turned white while in Audubon's possession, though this change of plumage is not directly stated to have occurred. I quote the brief description which, it will be readily seen, applies to *canadensis* and not to *americana*: "The trachea, which is thirteen inches long to its entrance between the crura of the furculum, passes into a cavity in the sternum where it curves so as to describe two-thirds of a circle, returns on the right side and enters the thorax by curving backwards. The cavity of the sternum is two inches long, with an equal depth, and a breadth of three-quarters of an inch. The ridge of the keel is, at its fore part, three-quarters in breadth, and contracts to one-half inch at its junction with the angle of the furcula, which is continuous with it. * * * * Boston specimen." It is strange that Audubon, who appears to have been a close

[1] Besides at page 530 of "Birds of the North-west," this description may also be found in full in *Forest and Stream* for Aug. 20, 1874.

observer of the general anatomical characteristics of his subjects, never examined the sternum of the adult *G. americana*, but only of what he considered the young. Yet we must conclude this to have been the case, for had it been otherwise, we certainly should not have been left with only the above description given without comment.

In conclusion, I cannot refrain from alluding to a subject which it were better, perhaps, to leave untouched at this time. In making careful, detailed comparisons of the several sterna in my possession, in order to determine exactly in what particulars the two species differ, I could but notice that only two important conditions need be fulfilled to change the sternum of *canadensis* into that of *americana*. If the remaining portion of the keel in *canadensis* were thickened and hollowed, and the trachea should gradually increase in length, the arrangement seen in *americana* would certainly result, for the disposition of the trachea in the latter species is exactly what would be produced by its forcing itself into the narrow limits of the keel. This may be simply an interesting relationship existing between the two structures, or it may have a deeper significance as the nature of the variations among the sterna of *canadensis* pointed out above, seems to imply. But considerations of this nature must be left for further investigation—until material of a determinative kind has been obtained.

EXPLANATION OF CUTS.

FIG. 1.—Sternum and lower part of trachea of the sandhill crane, *G. canadensis*. The left wall of the cavity has been removed, showing the trachea coiled away inside.

FIG. 2.—The same of the whooping crane, *G. americana*. The entire left side of the keel has been cut away to show the interior. The scapulars, clavicles and coracoids are in position in each.

These drawings were very kindly made for the illustration of this article by my friend, Mr. C. L. Herrick. They are about one-half natural size.

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THE DEVELOPMENT OF MOINA.[1]

BY J. S. KINGSLEY.

DR. Carl Grobben having recently published one of the most complete accounts of the development of one of the Daphnidæ which has yet appeared, an abstract of his paper may prove of value to American naturalists.

[1] Die Entwickelungsgeschichte der *Moina rectirostris*. Arbiten aus dem Zoologischen Institute der Universität. Wien. Tom. II, 2 heft, 1879, pp. 66, pls. 7.